Daytime Cloud Shadow Detection With MODIS

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Goal:

To use clear-sky reflectance maps to help filter clear-sky pixels that contain cloud shadows

Note: Not trying to detect cloud shadows on clouds

Approach:

Comparison of measured to clear-sky weekly composite reflectances at 1.6 μm

Data required:

- MOD021km and MOD03

- MOD35 - Cloud mask

- clear-sky weekly composite (25 km resolution, 8 bands, includes 1.6 μm)

Approach

From Level1B data:

- filter out water pixels (land-water mask in MOD03)
- filter out cloud pixels (cloud mask MOD35)

Clear-Sky Weekly Composite:

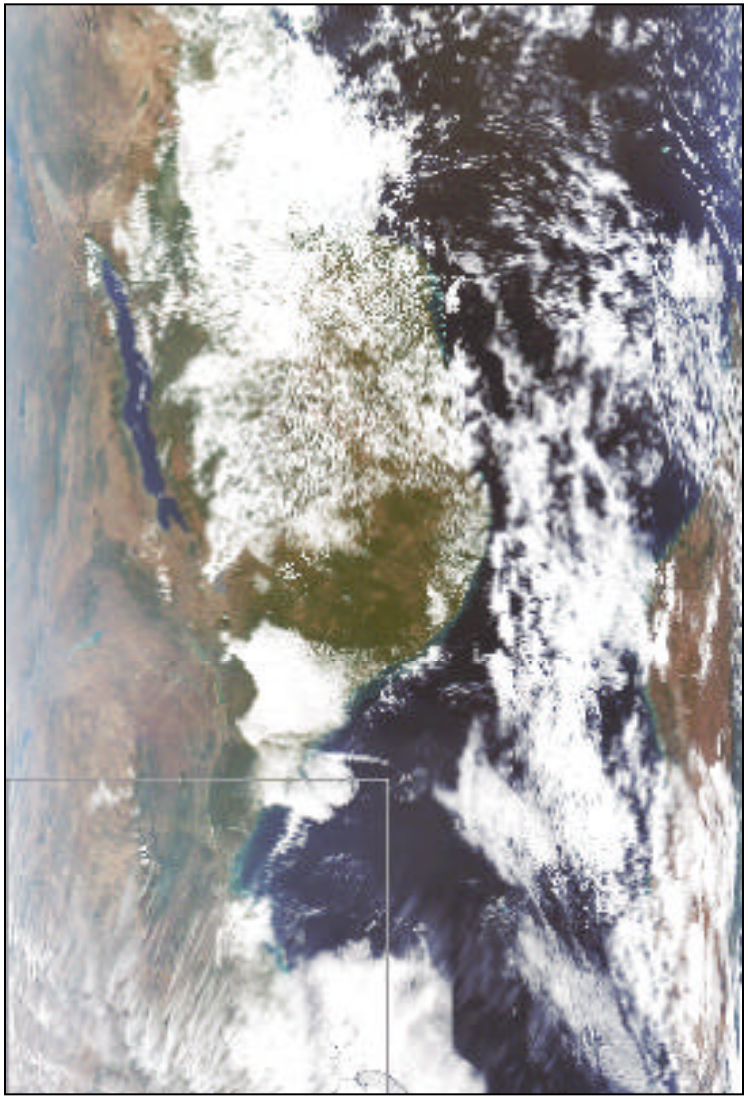
- creating subset of global 1.6 µm-daytime-reflectance composite map

Algorithm:

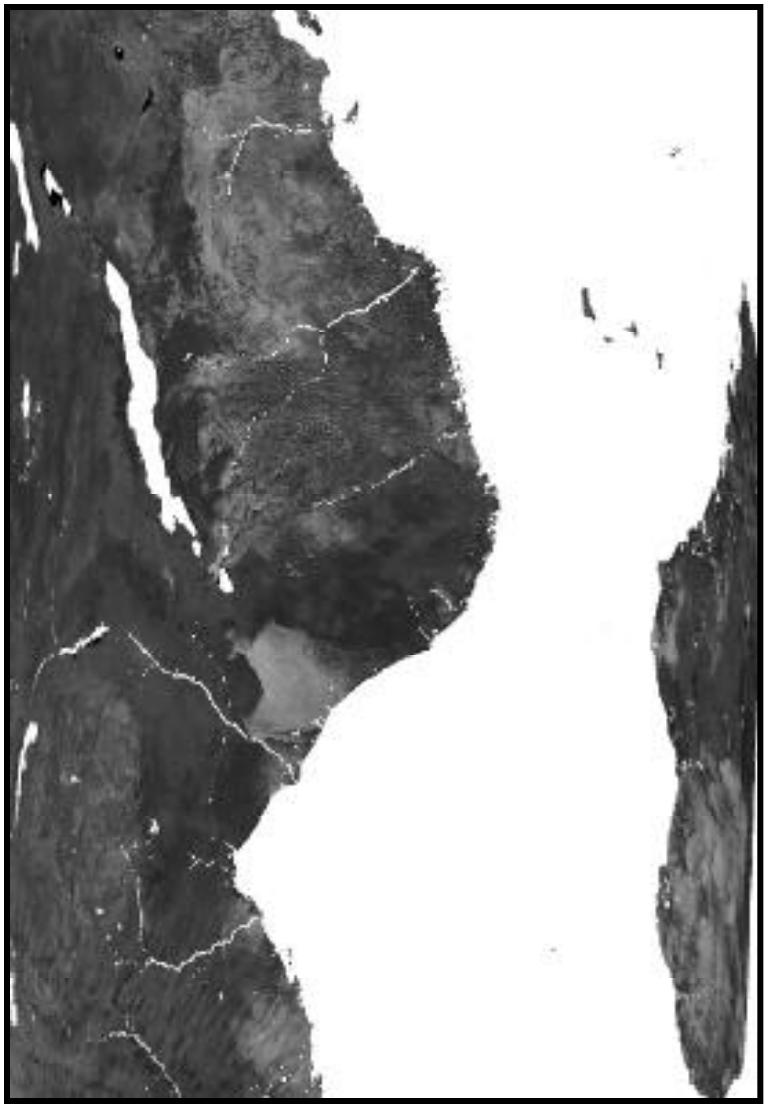
compare reflectance of clear-sky image and level1B image

set threshold as percentage of clear-sky value (e.g. 80%)

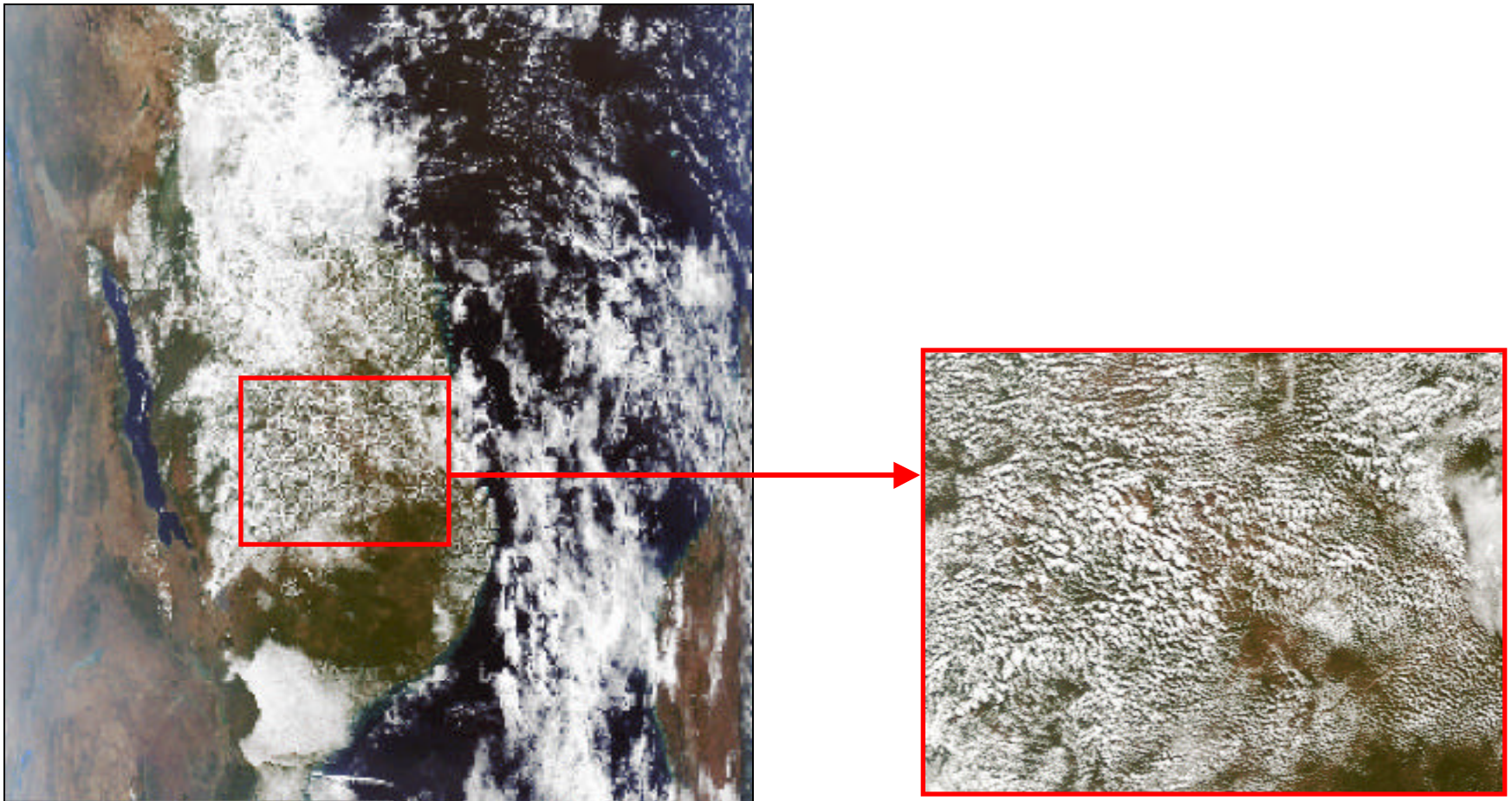
pixels with values lower than the threshold are flagged as shadow pixels

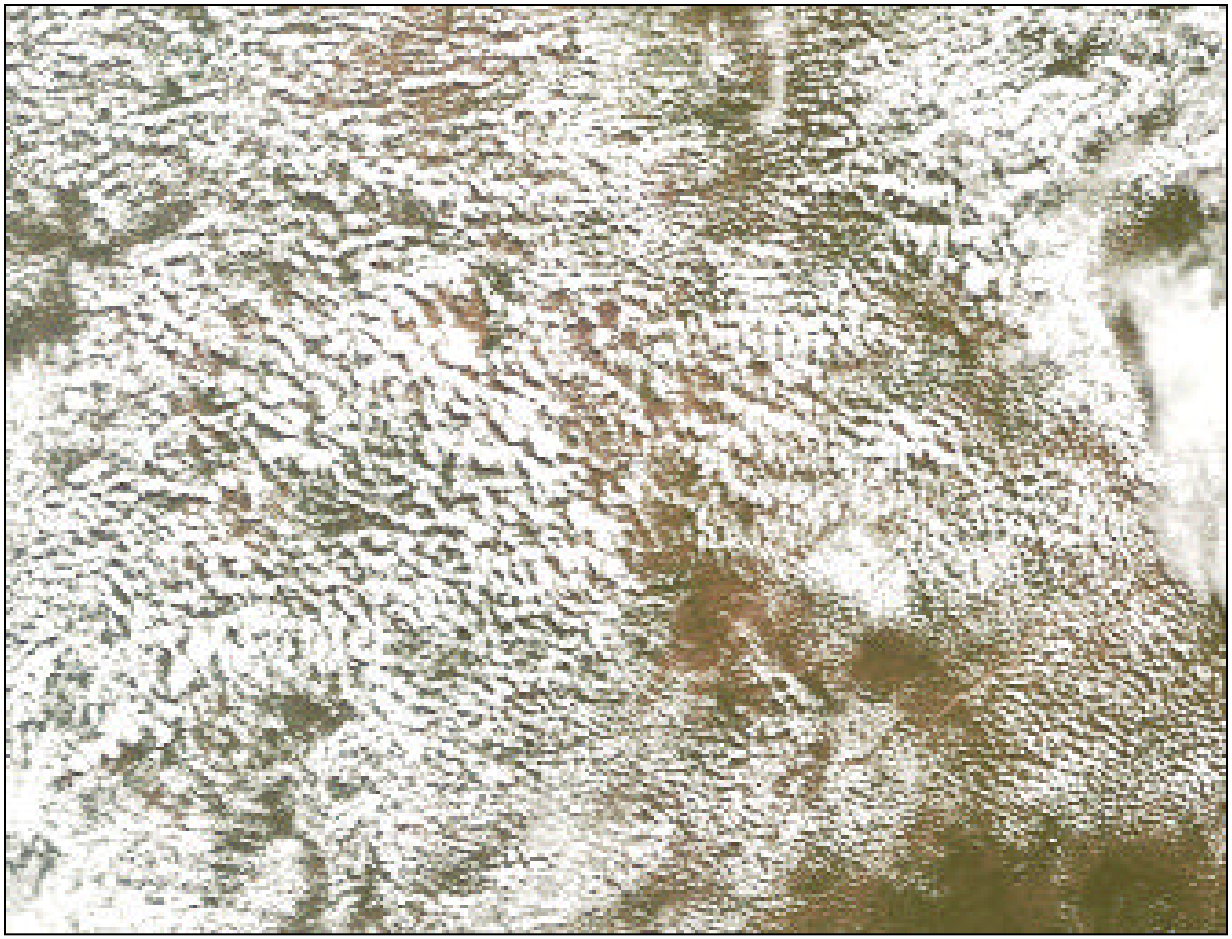


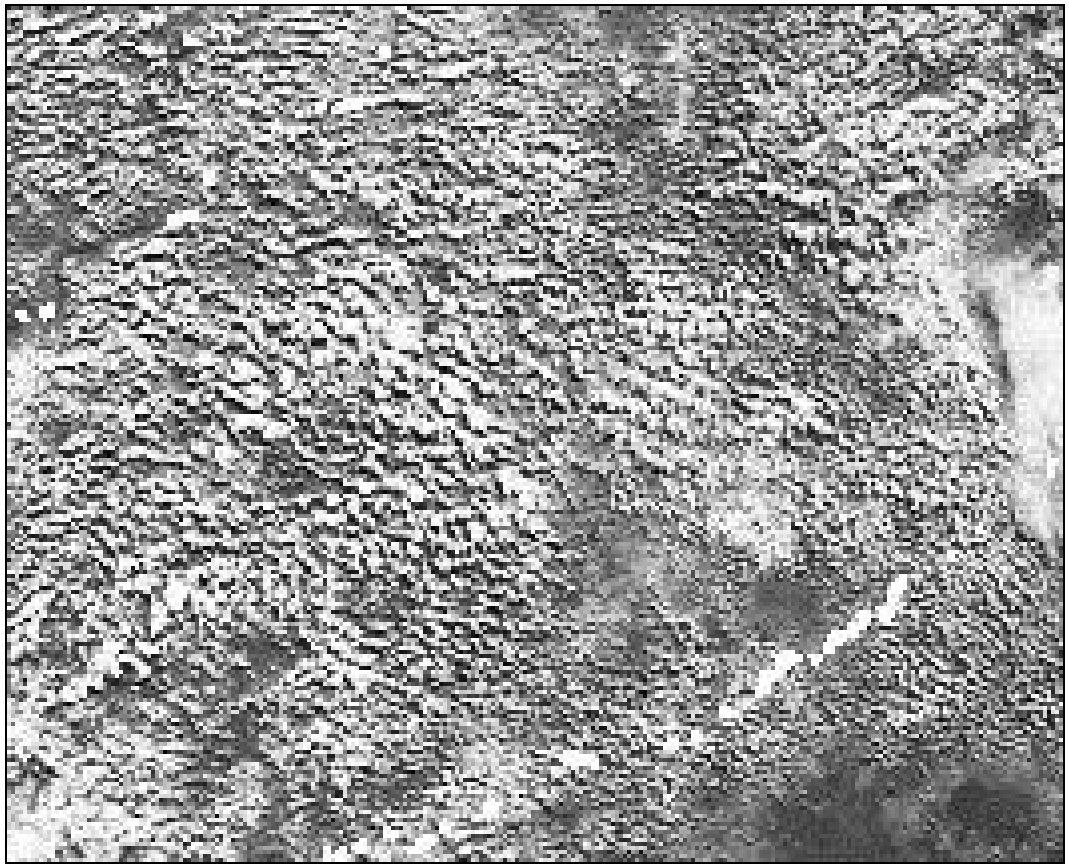
MODIS-RGB-Composite of Eastern Africa
(29 June2002, 07:45 UTC)

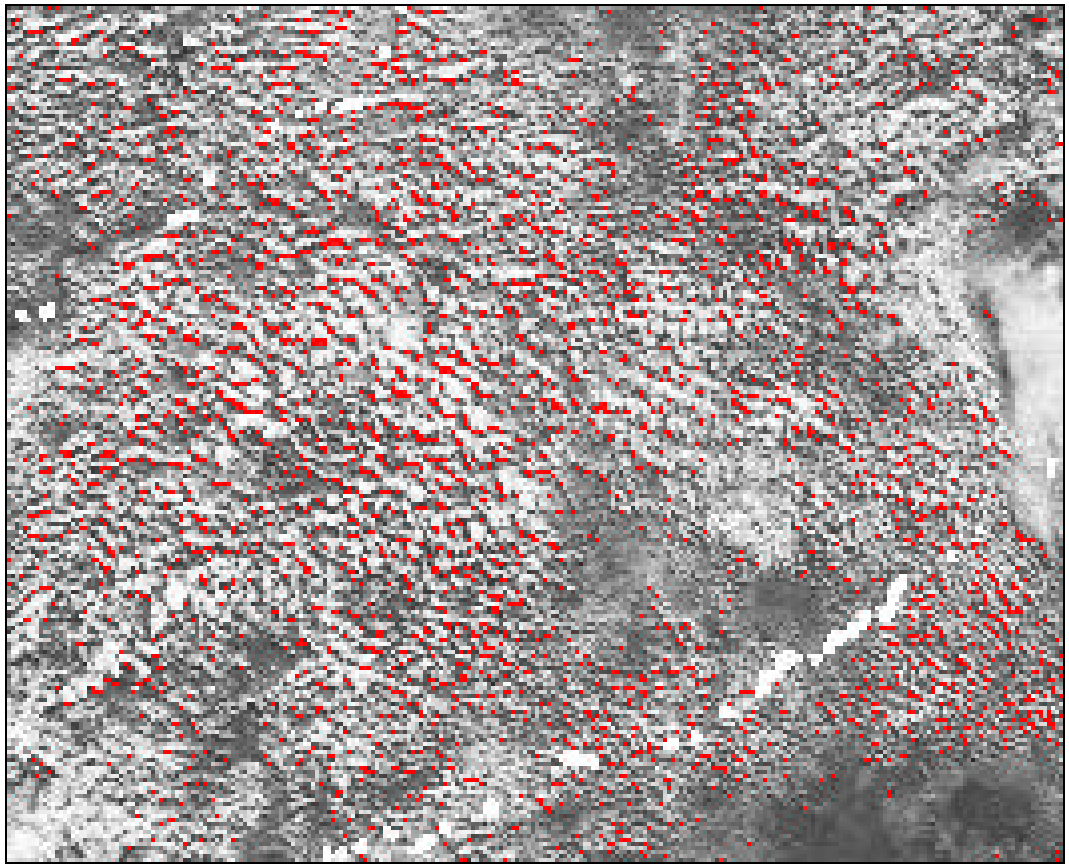


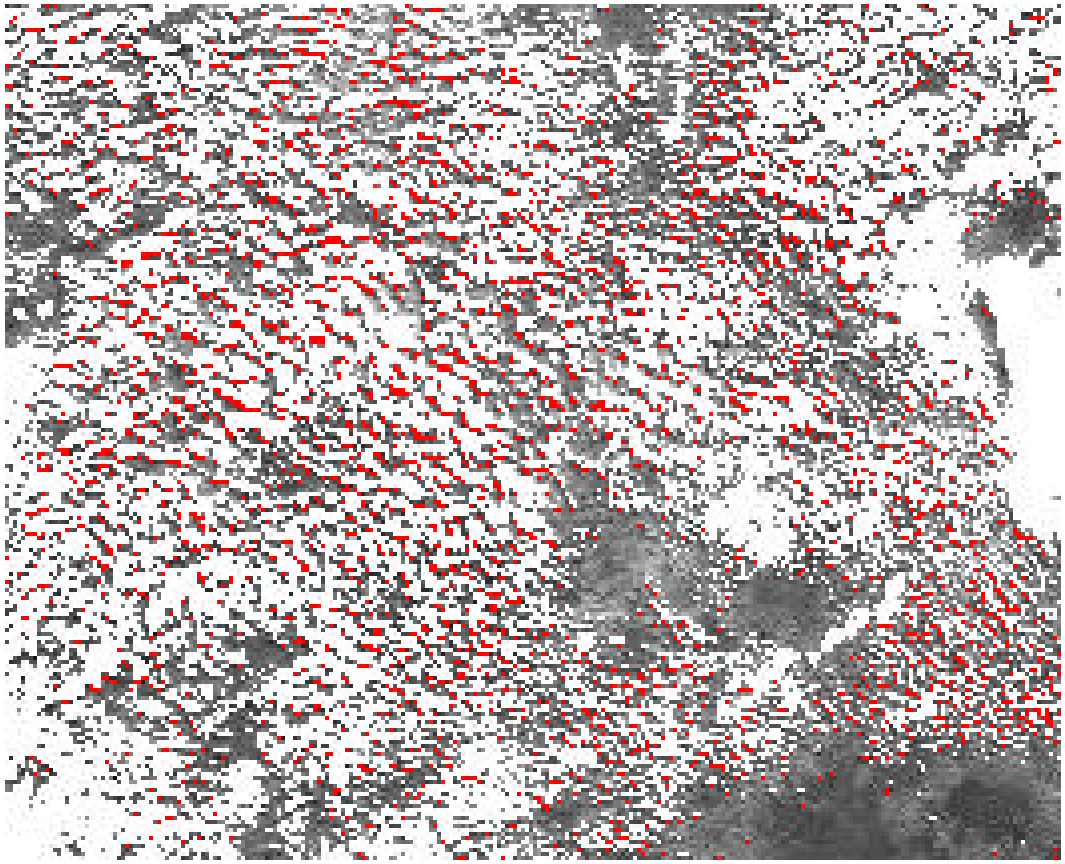
1.6-μm reflectance with water pixels filtered out of image



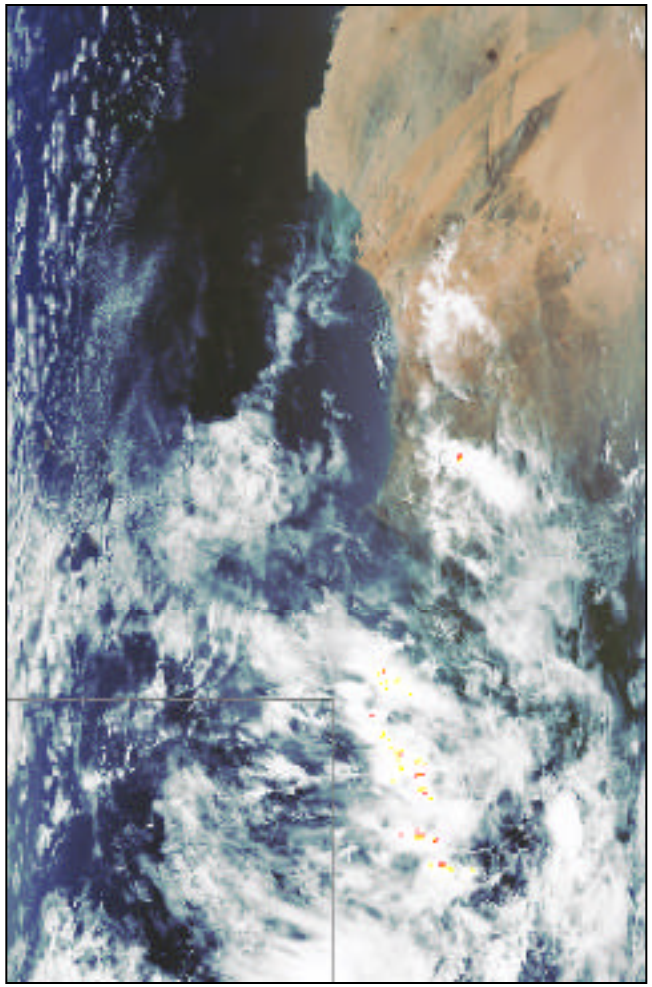








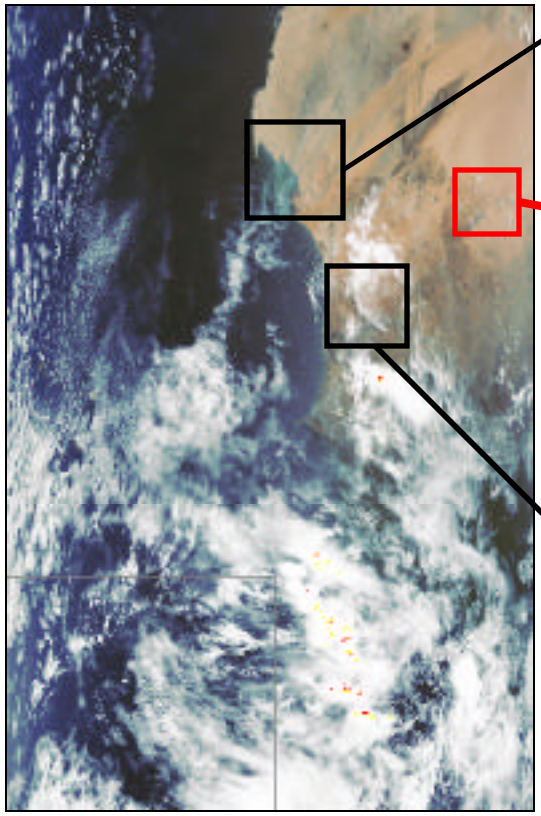
Study area: West Africa

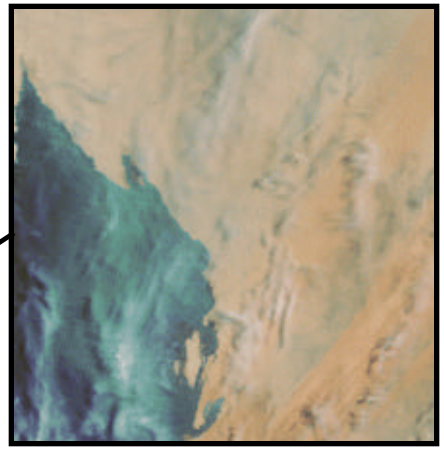


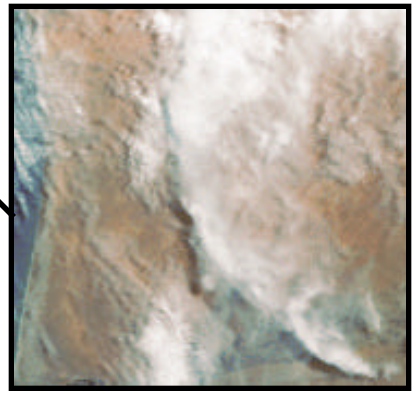
MODIS-RGB-Composite of Western Africa
(28 June2002, 11:50 UTC)

Clear-Sky Weekly Composite
(25 km resolution)

Location of example areas







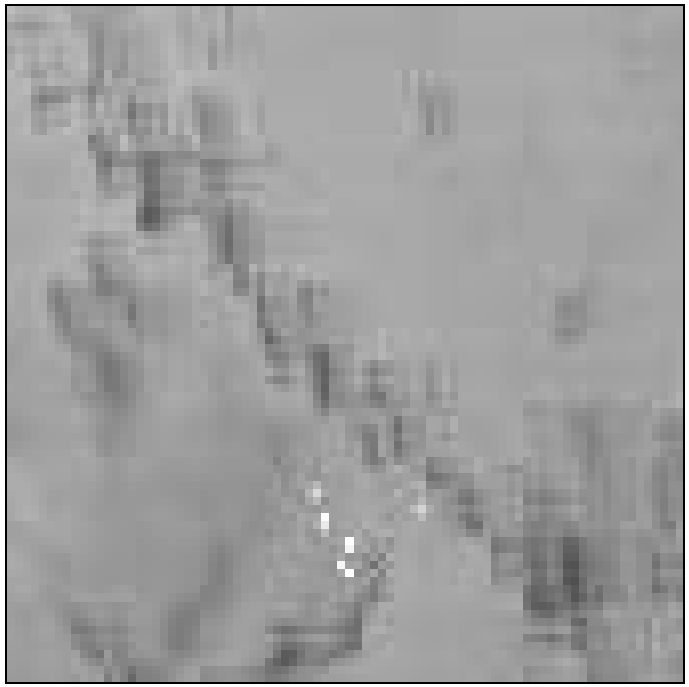
RGB-composite of area 1

- Mauritania
- water clouds over desert
- surface has a very high reflectance
- little if any vegetation

0.65 µm-Reflectance

Clouds brighter than surface

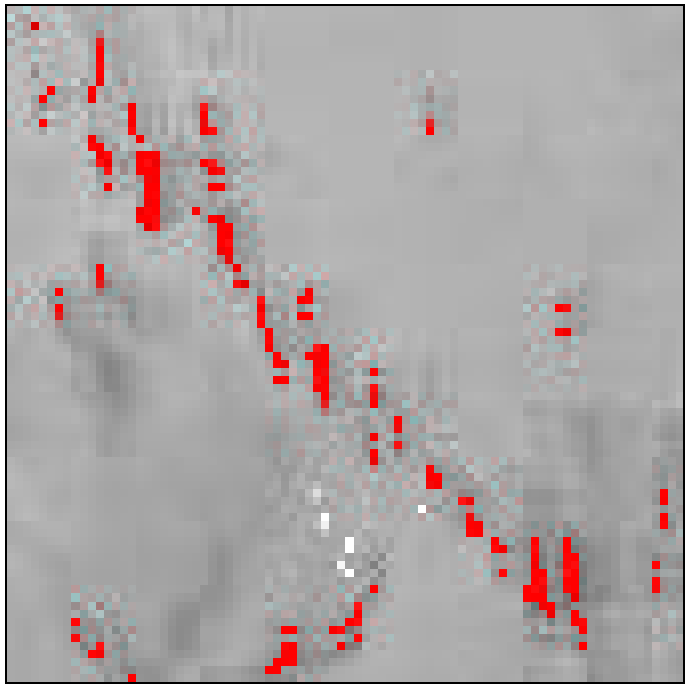
1.6 µm-Reflectance



Surface brighter than clouds

0.65 µm-Reflectance

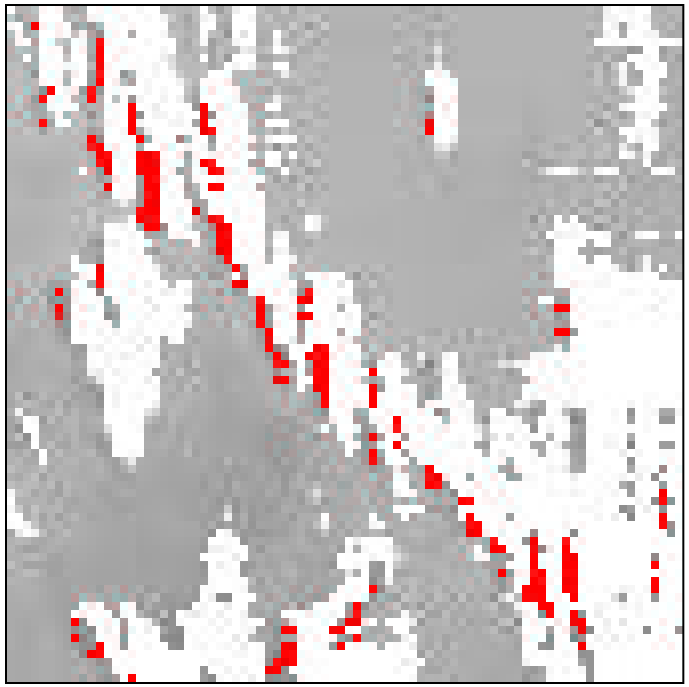
Shadow detection



Shadows are red

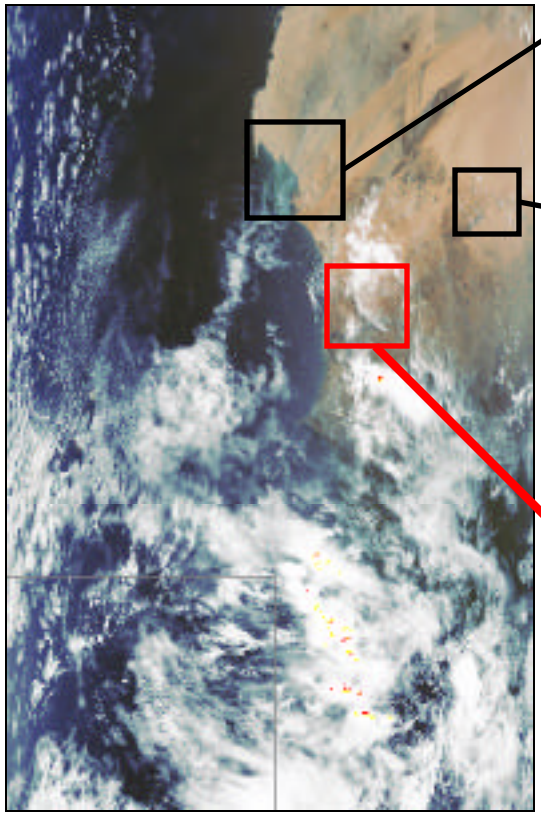
0.65 µm-Reflectance

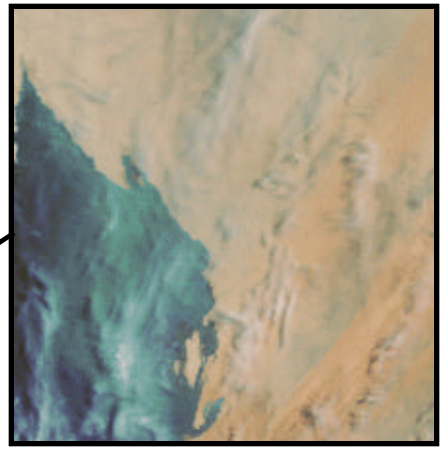
Shadow detection
(combined with cloud mask)

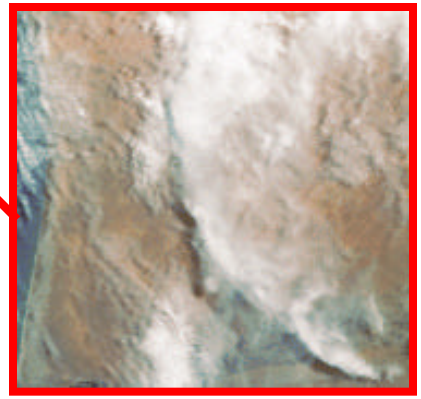


Shadows adjacent to clouds

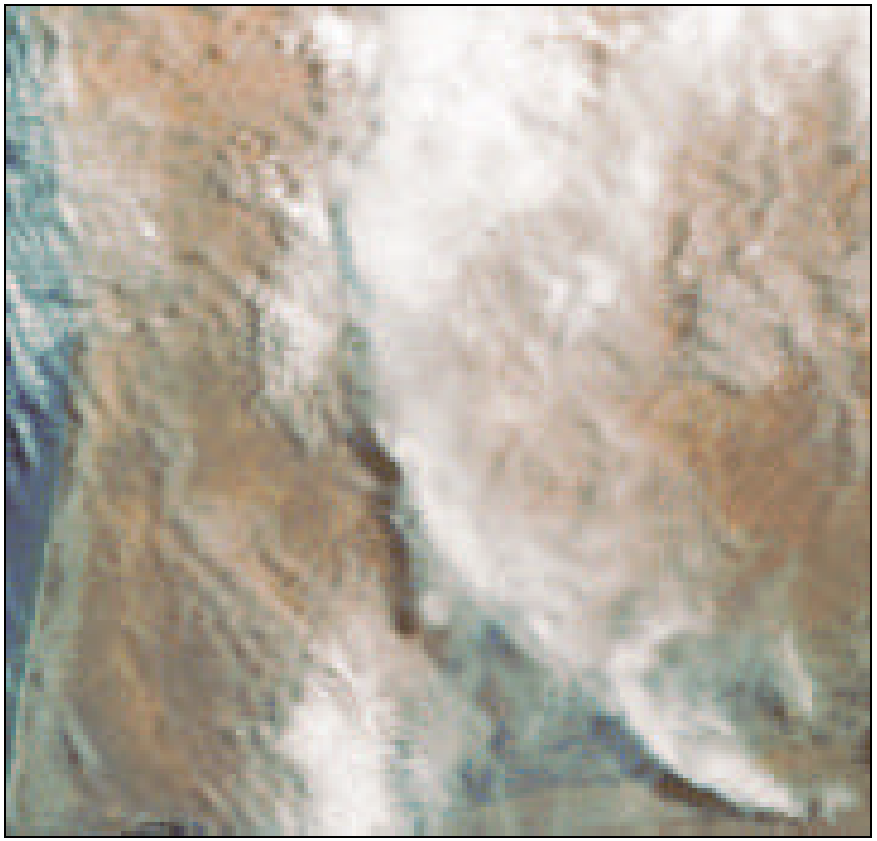
Location of example areas





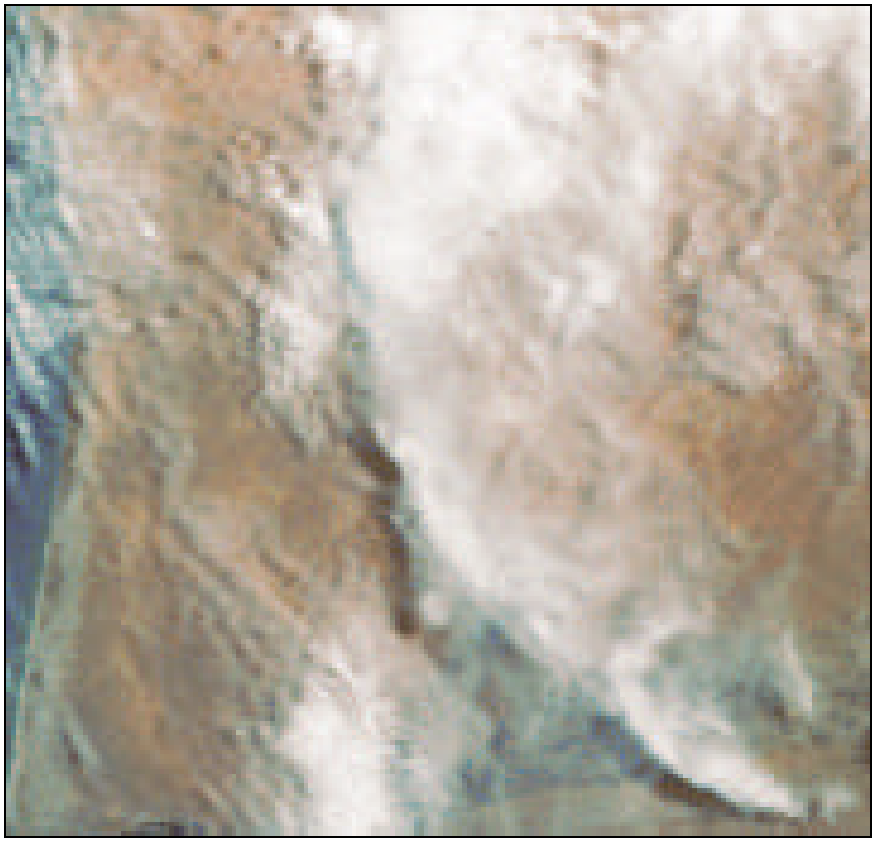


RGB-composite of area 2

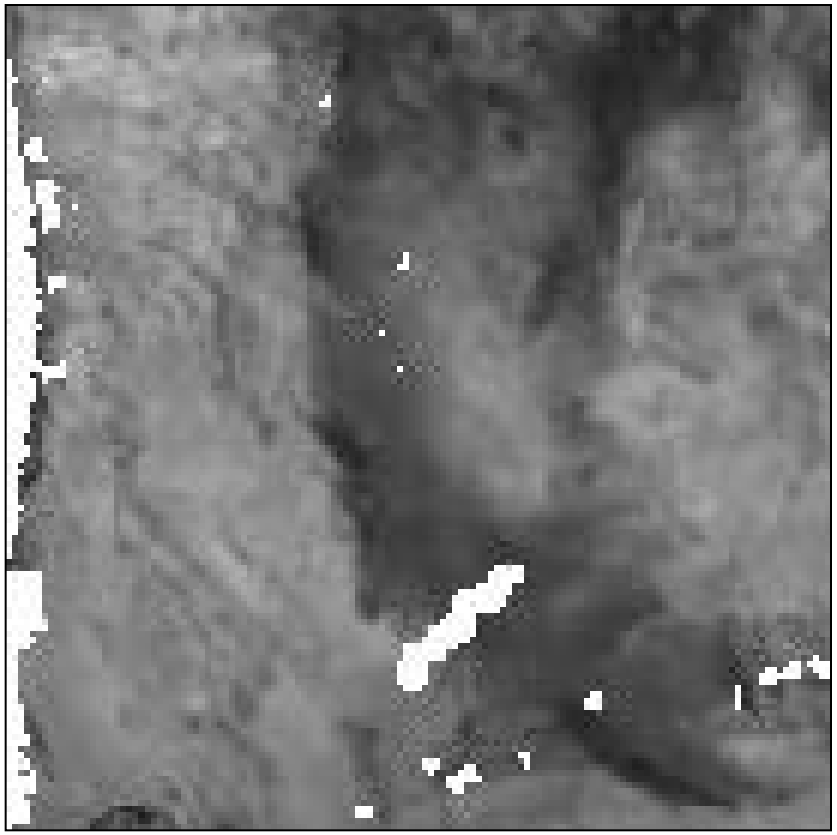


- Mauritania - Senegal
- desert-like area
- crossed by Senegal river
- mainly ice clouds

RGB - Composite

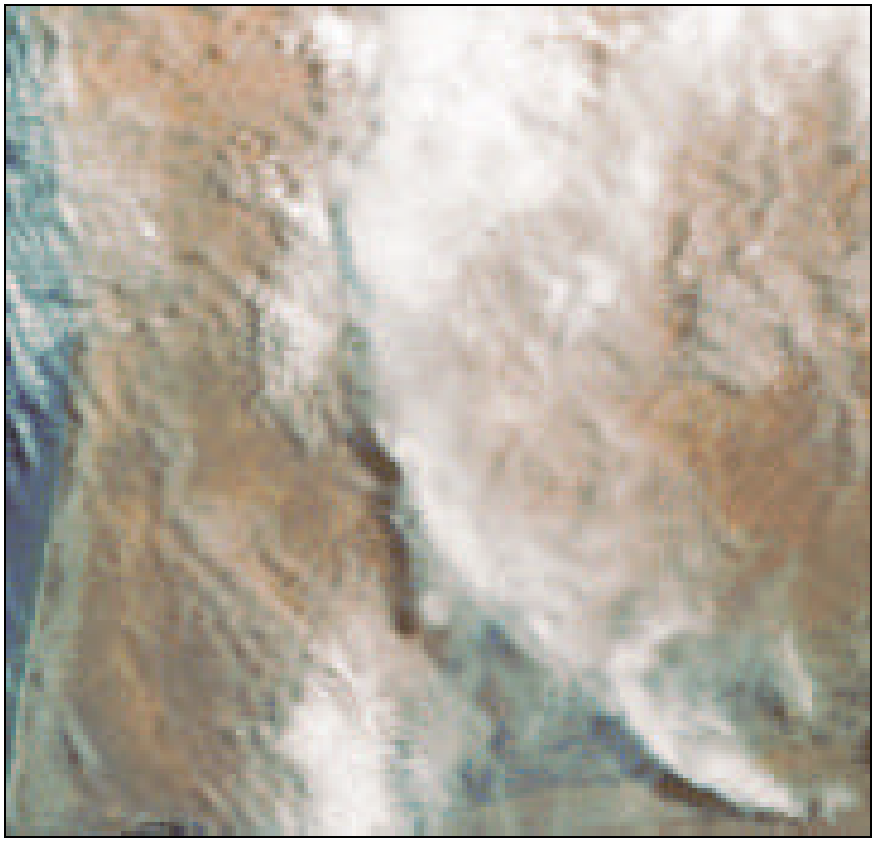


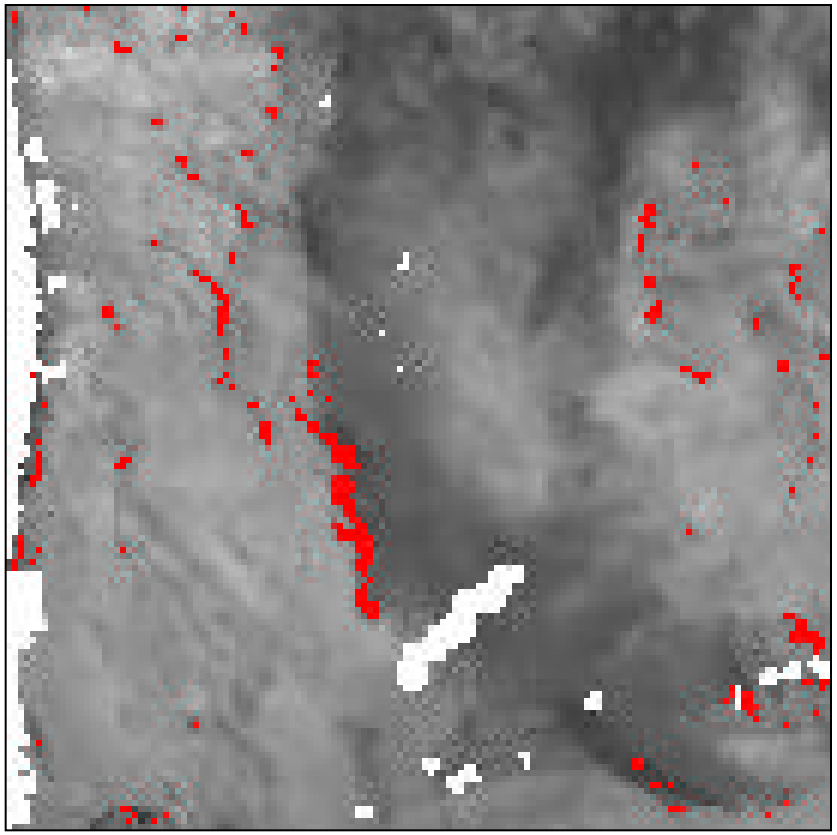
1.6 µm-Reflectance



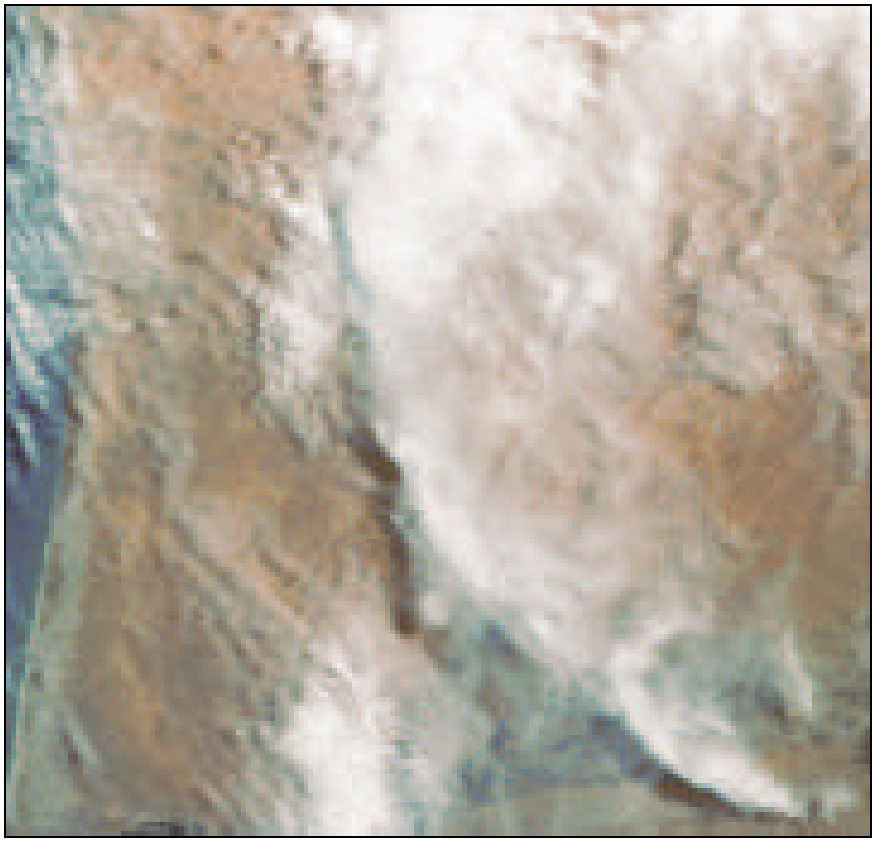
- shadows on eastern edge
- Senegal river not well detected by land-water mask

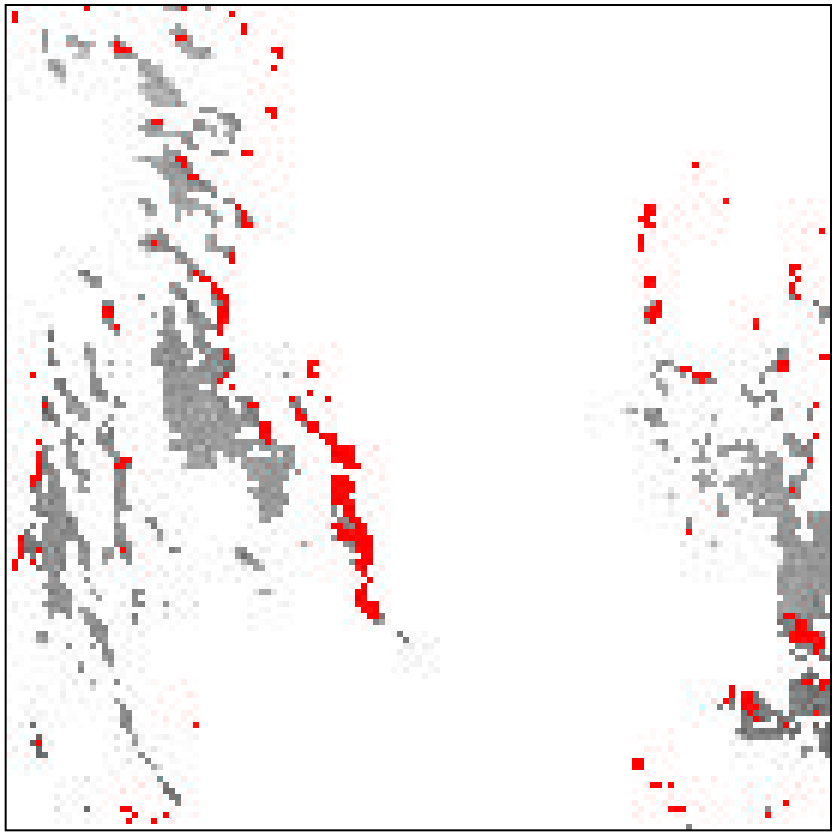
Shadow detection





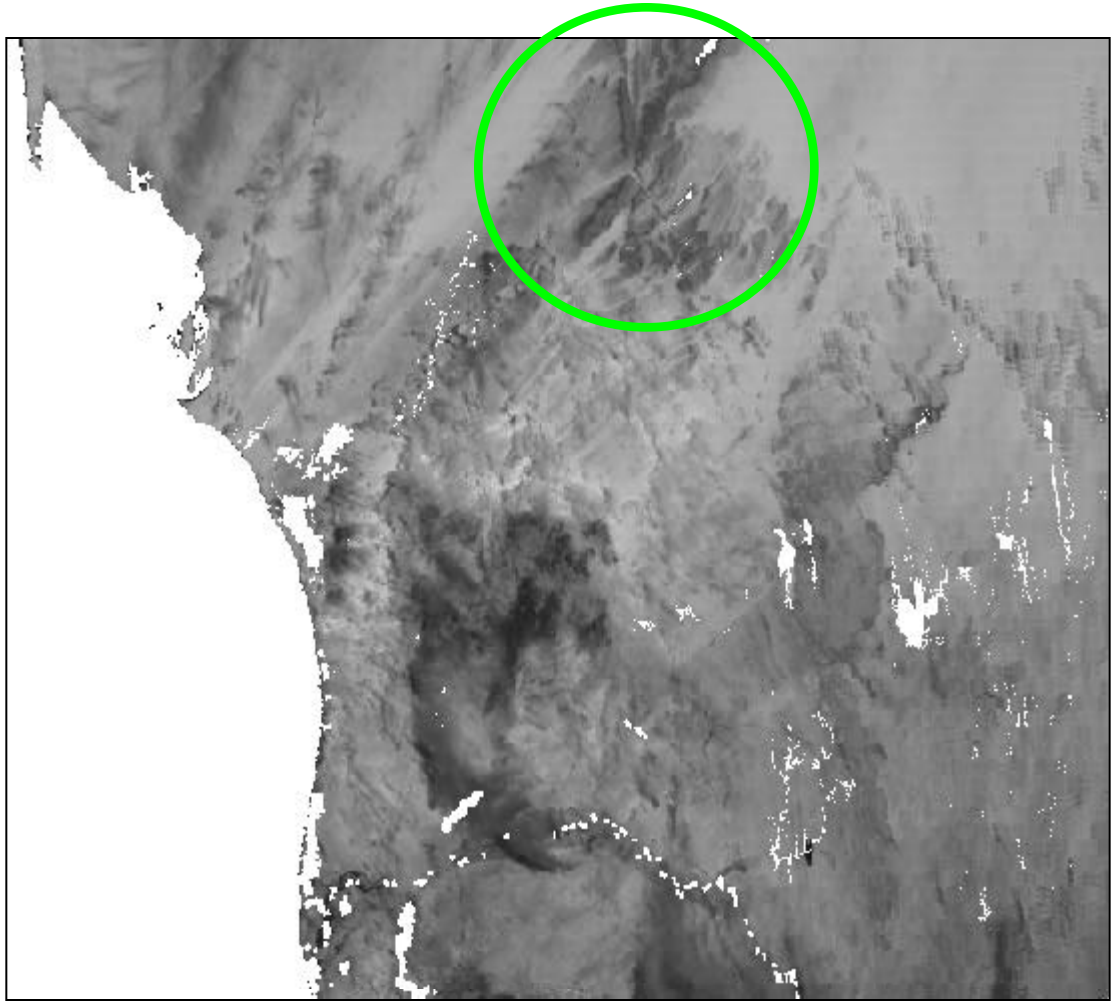
Shadow detection
(combined with cloud mask)





not detected shadows are often
already detected as cloud

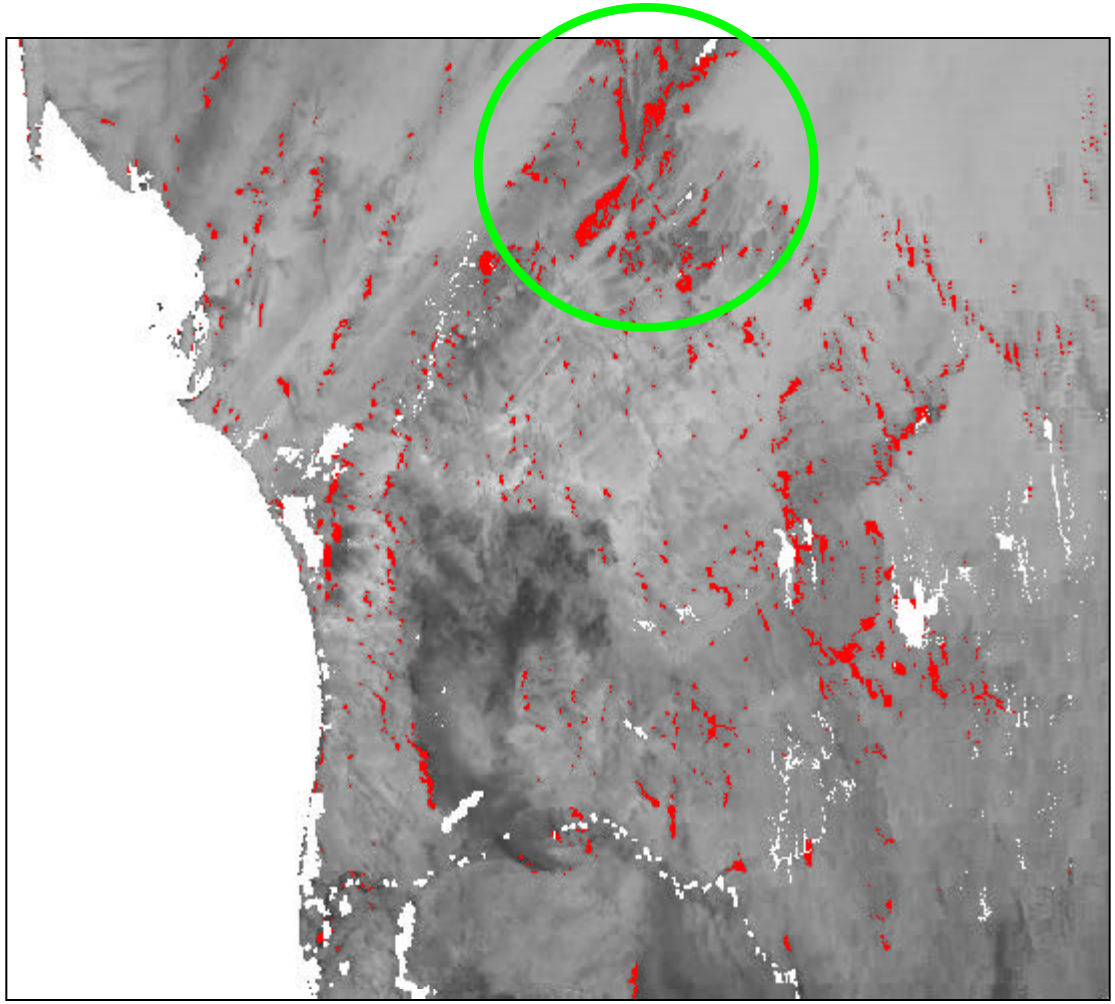
1.6 µm-Reflectance overview



high diversity of soil types in the north (diverse reflectance)

1.6 µm-Reflectance overview

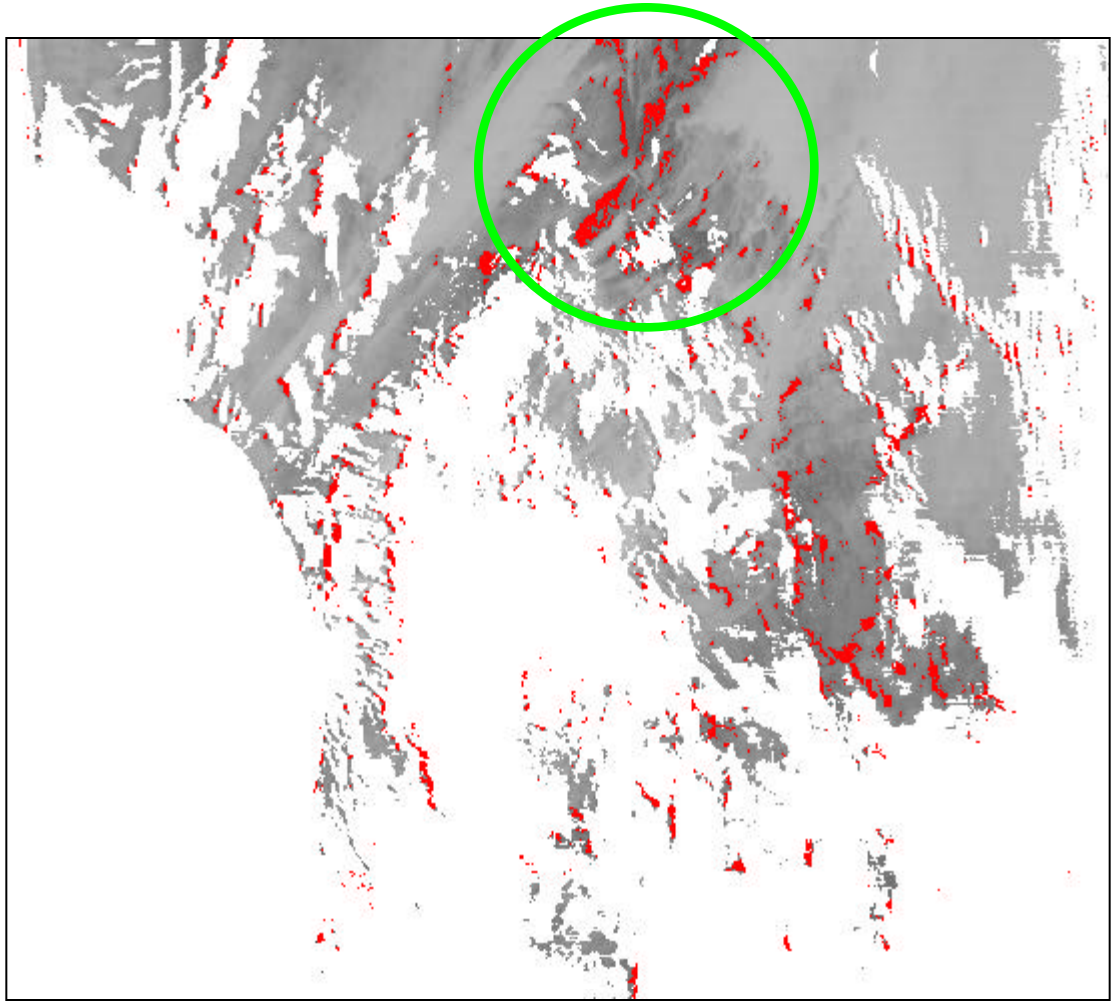
including detected “cloud shadows”



darker parts detected as shadows

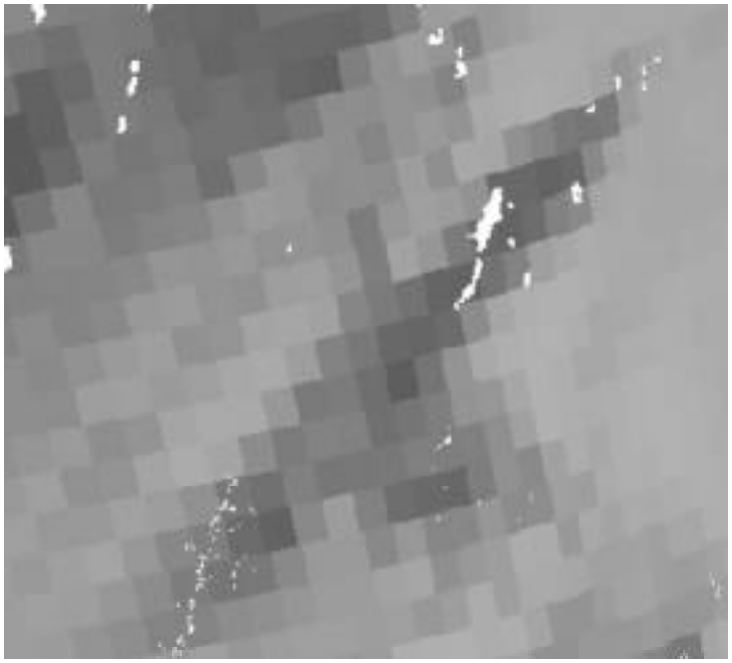
1.6 µm-Reflectance overview

including falsely detected cloud shadows and cloud mask

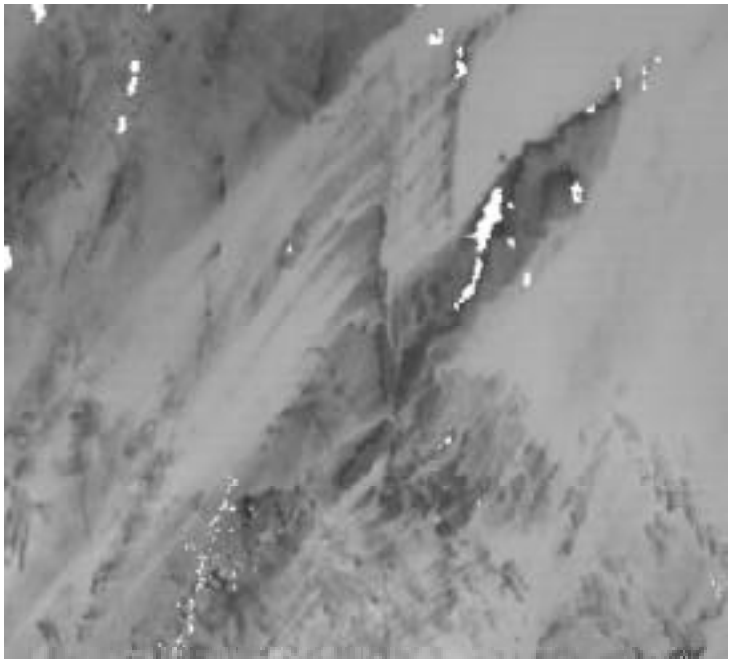


Cloud mask indicates that shadows are falsely detected
(possibly because of coarse resolution of clear-sky reflectance map)

Spatial resolution problem

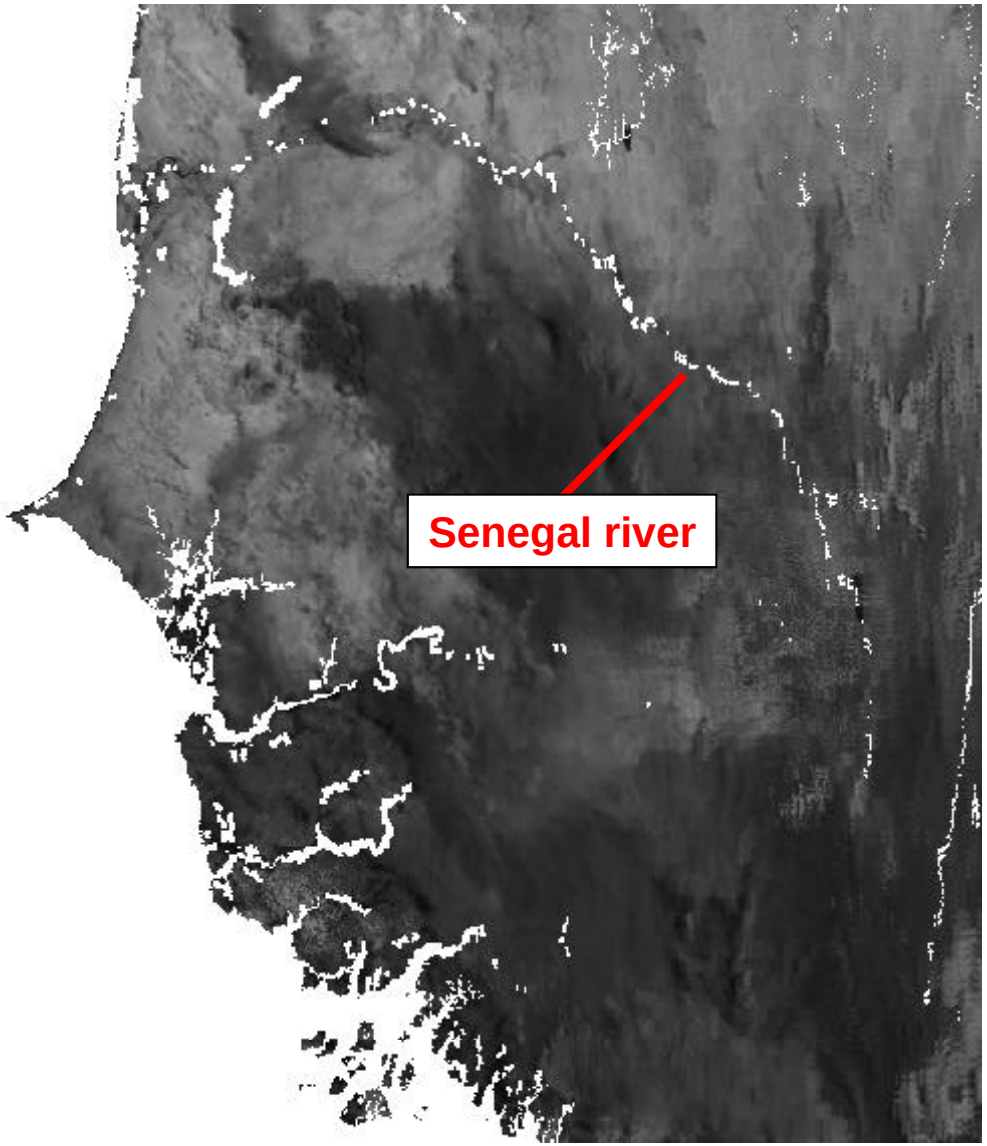


25 km - resolution
Clear-sky map



1 km - resolution
MOD021km (1.6 μm)

Land-water mask



Conclusion

Initial attempt to detect cloud shadows by comparing images with clear-sky composites is encouraging

Suggested improvements

- shadows should be next to clouds
- improve spatial resolution of clear-sky reflectance map
- can we find a higher resolution land/water mask?
- might improve detection of nondetected cloud shadows by checking nearest-neighbor pixels and relaxing threshold criteria

Problems:

- spatial resolution of clear-sky map
- setting threshold
- land-water mask
- cloud mask

Suggested improvements

- shadows should be next to clouds
- finding missing cloud shadows by pixel walking

Additional

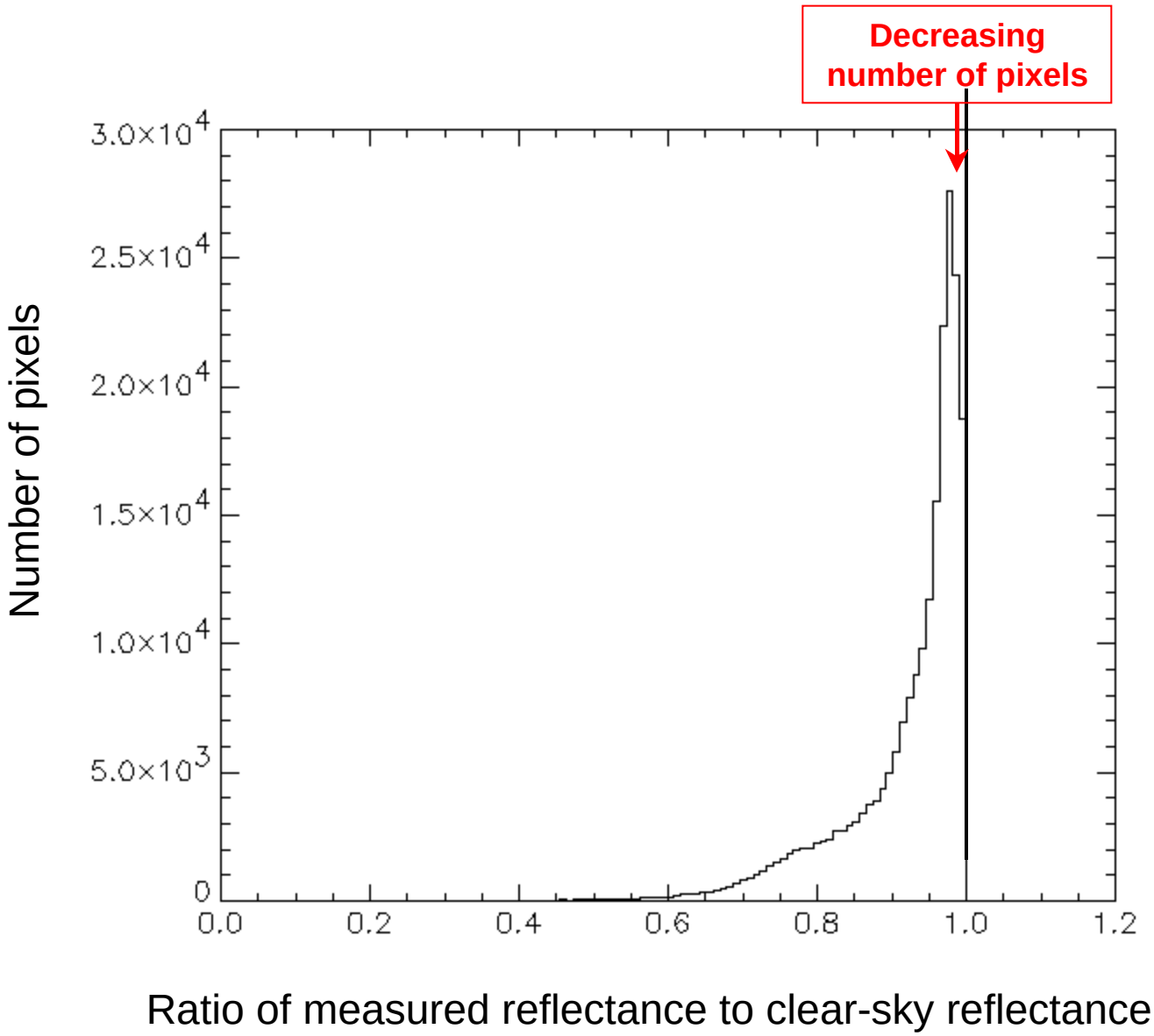
Attempt to set the threshold

by using histograms

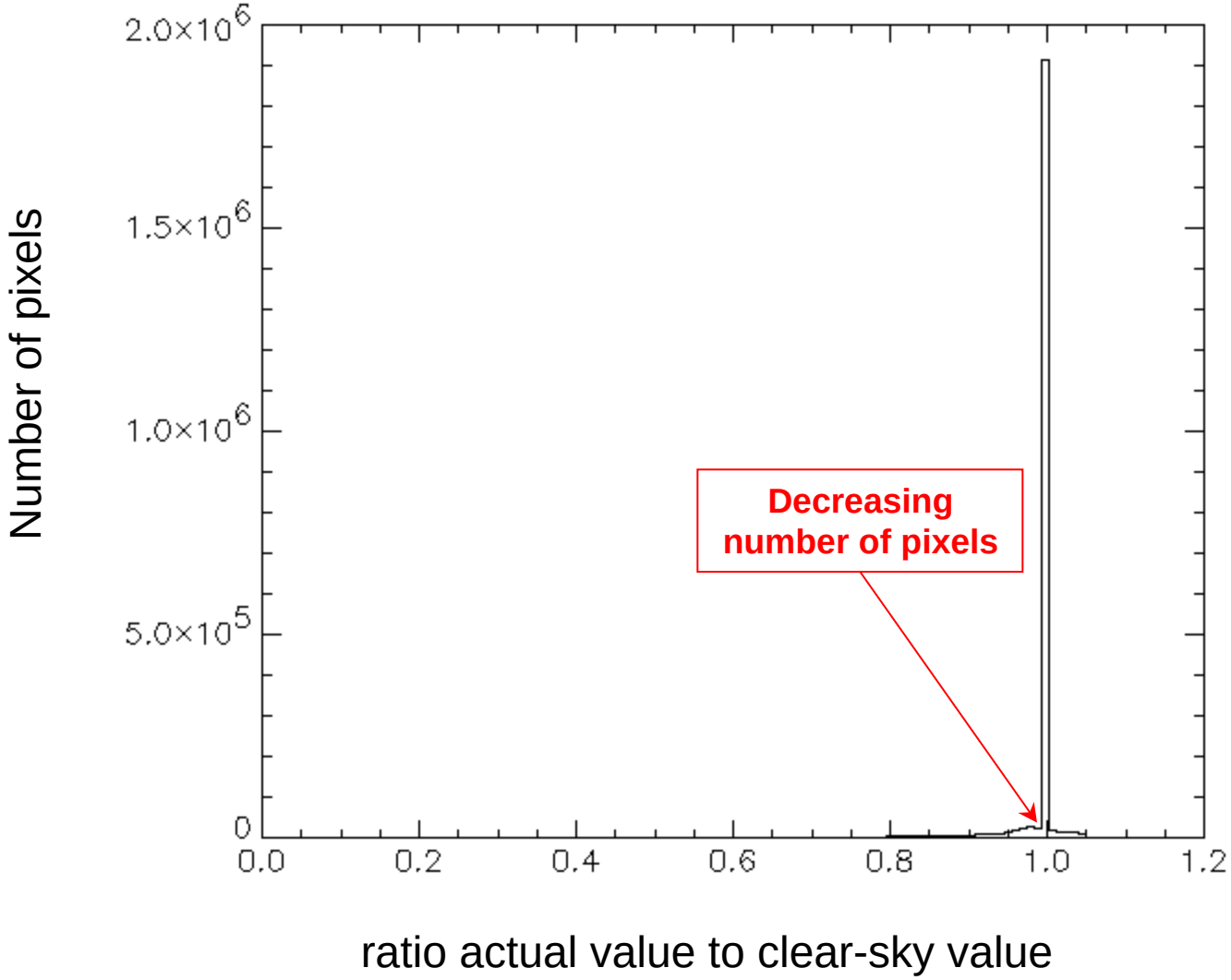
Question:

Is there any “natural” threshold ?

Histogram-based threshold



Histogram - 1.05 threshold



Preliminary indications

- seems that threshold could be set by use of histograms
- in this example it could be set higher than 0.8
- but... the share of false shadows might be higher
- would help to have a clear-sky map with higher spatial resolution

Additional Areas

Location of example areas